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(54) **Functionally modifiable cable television converter system.**

(57) A cable television converter with remotely modifiable functionality receives firmware downloaded over a cable television network. The integrity of the firmware is verified and if valid, the firmware is executed to provide one or more converter functions. If the firmware is invalid, default operation software contained in ROM is executed instead of the firmware to return the converter to baseline operation. In one embodiment, the converter includes a frequency agile data receiver to receive control instructions on a first data channel and firmware on a second data channel. The receiver is forced back to the first channel if a successful firmware download does not occur on the second channel within a predetermined time period. The firmware is continuously transmitted in short segments, and the converter can continue to receive segments until all the segments of a designated firmware package have been successfully downloaded, unless the predetermined time limit expires sooner.

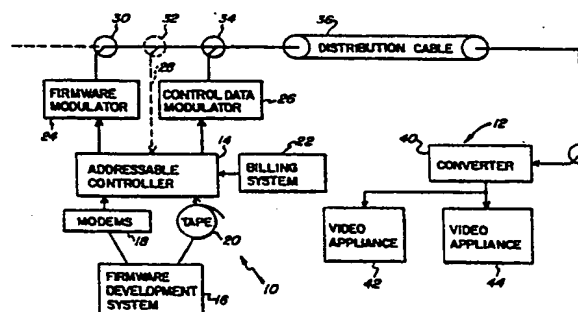


FIG. 1

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are provided for verifying the integrity of the firmware, and processor means coupled to the storing means accesses and executes the firmware to provide one or more converter functions dictated by the firmware. Nonvolatile memory means are coupled to the processor means for storing default operation software for the converter. Means responsive to the verifying means cause the processor means to execute the default operation software, instead of the downloaded firmware, in the event the integrity of the firmware is not verified.

Data receiving means may be provided for obtaining instructions downloaded over a cable television network. Downloaded firmware is received and stored by the converter only in response to specific instructions received by the data receiving means.

The firmware receiving means and data receiving means can comprise a frequency agile data receiver, together with means for selectively tuning the receiver, to receive instructions on a first channel and downloaded firmware on a second channel. Timer means return the receiver to the first channel if the receiver has been tuned to the second channel for a predetermined time period. The predetermined time period may be specified in instructions received on said first channel, and the length of the time period may be dependent on an amount of firmware to be received. In this manner, a converter will not become stuck on the second channel by error, and be rendered unable to receive further instructions on the first channel.

The downloaded firmware received and stored by the converter can implement a functional layout on a keyboard associated with the converter. Firmware can also implement a feedback function, such as an LED (light-emitting-diode) display or on-screen display to assist a user in operating the converter. A control function for a video recorder coupled to the converter can also be implemented by the firmware. Similarly, the firmware can implement a communication protocol for the converter, a descrambling technique for the converter, an on-screen display to be provided by the converter to a television coupled thereto, and/or a user interface to services provided over the cable television network.

In a preferred embodiment of the present invention, firmware is transmitted in an encrypted form, and the instructions contain a key for decrypting the firmware. The firmware may also be received by the converter in a plurality of segments, with the instructions identifying the number of segments to be received for a complete firmware download. Means can be provided for determining if all of the segments have been validly received, and for receiving replacement segments if one or more segments of the firmware have not been

validly received. Receipt of firmware can be prevented if the number of segments identified by the instructions is greater than a predetermined limit.

Cable television headend apparatus is provided for downloading firmware to an addressable, remotely modifiable cable television converter. Means are provided for transmitting addressable converter data on a first data channel of a cable television network. Means are provided for transmitting firmware on a second data channel of the cable television network. An address specific to a particular converter is provided in the addressable converter data, which enables specific data to be received by the converter. Instructions are provided in the specific data, to cause the converter to receive firmware transmitted on the second channel.

The cable television headend apparatus can further include means for verifying that firmware downloaded to the converter has been successfully received by the converter. Billing means maintain records of the cable television services each converter on the system is authorized to receive, and the various functions the converter is to have, and can assign a particular firmware package to be downloaded to a particular converter on the basis of the functions specified for that converter.

A method for providing a cable television converter with functions dictated by downloaded firmware is also provided. Converter control data is received from a remote location via a cable television network. A designated firmware package is captured from a set of firmware packages carried on the cable television network, in response to instructions contained in the converter control data. The designated firmware package is stored in a memory provided in the converter, and is executed to provide at least one converter function dictated thereby.

The firmware packages may be carried on the cable television network in encrypted form, and decrypted using a key contained in the converter control data. In one embodiment, the converter control data is received on a first data channel and the firmware packages are captured from a second data channel on the cable television network. The first channel is monitored to receive converter control data, and the second channel is tuned to capture firmware upon receipt of appropriate instructions on the first channel. Reception is returned to the first channel after the firmware is captured. If the firmware has not been captured within a predetermined time period, reception switched back to the first channel from the second channel.

Also in accordance with the present invention, a remotely modifiable user terminal is provided which comprises means for receiving a plurality of cyclically transmitted firmware segments, the seg-

may optionally be provided via tap 32 for receipt of data from converter 40 by addressable controller 14. Such data might include, for example, a verification that converter 40 has successfully received a firmware package it has been instructed to receive. The provision of a return path 28, which provides a "two-way" cable communication system, is well known in the art.

Billing system 22 is provided at the headend for maintaining accounting information relating to charges incurred by subscribers on the cable system. In accordance with the present invention, different firmware packages downloaded by headend 10 to converter 40 may provide different converter functions, with higher levels of service providing increased converter functionality. Billing system 22 keeps track of the level or service for each subscriber, and assigns particular firmware packages to subscriber converters on the basis of converter functionality to be provided to each subscriber.

At the subscriber location 12, a subscriber may have one or more video appliances 42, 44 coupled to the output of converter 40. For example, video appliance 42 might be a television set, and video appliance 44 might be a video recorder ("VCR"). In accordance with the present invention, firmware downloaded to converter 40 can provide functions relating to a VCR. An example of such a function is time controlled programming. This function enables the converter to be programmed to make channel changes at various times so that the VCR can record different television programs on different channels automatically and while unattended. Such a function can also enable "impulse pay-per-view" orders to be programmed into the converter by a subscriber, so that special premium programs can be ordered, when the subscriber is not home, and recorded on the subscriber's VCR for later viewing.

Figure 2 is a block diagram illustrating the pertinent components in one embodiment of a converter 40 in accordance with the present invention. In the embodiment illustrated, the converter receives addressable data on one data channel and downloaded firmware on another data channel. It is noted that in another embodiment of the invention, both the addressable data and the firmware can be received over a single data channel. Or, the firmware may be carried on some other media, such as the public telephone network.

In the two channel embodiment illustrated in Figure 2, a microprocessor 50 receives data from cable 36 via a frequency agile receiver 52. A transmitter 61 and return path 62 can be provided from microprocessor 50 back to addressable controller 14 in the event the converter is used with a two-way cable television system. Like receiver 52, transmitter 61 can be frequency agile to enable a choice of return transmission frequencies.

A tuner 54, under the control of microprocessor 50, tunes frequency agile receiver 52 to either a primary channel for receipt of addressable data (e.g., instructions to capture a particular firmware package) or to a secondary channel for the receipt of firmware. Although a single secondary channel is described herein for purposes of illustration, it will be appreciated that any number of such secondary channels can be provided, depending on system requirements. Typically, frequency agile receiver will be tuned to the primary channel, and will only switch to the secondary channel upon specific instructions contained in data received on the first channel. In the alternate embodiment where both addressable data and firmware are received on a single data channel, frequency agile receiver 52 and tuner 54 can be replaced with a fixed frequency data receiver.

The provision of a dedicated secondary data channel as illustrated in Figure 2 is advantageous. By keeping firmware data off of the primary channel, the data throughput load on this channel is reduced.

In the two channel embodiment, firmware data is broadcast cyclically on the second channel, by addressable controller 14 at the headend. In a preferred embodiment, a plurality of different firmware packages are broadcast on the secondary channel, each package providing different converter functions or combinations of functions. Upon receipt of instructions on the primary channel, microprocessor 50 will cause tuner 54 to switch receiver 52 to the secondary channel for receipt of a designated firmware package.

Various memory devices are coupled to microprocessor 50, including read only memory ("ROM") 56, operating random access memory ("RAM") 58, and nonvolatile firmware RAM 60. ROM 56 contains a program that allows converter 40 to retrieve and execute a downloaded firmware package. Upon receiving the proper command from the addressable controller, the converter aborts any downloaded package currently being executed, accesses the appropriate data channel for receipt of a designated firmware package to be downloaded, and receives and loads the firmware into non-volatile firmware RAM 60.

ROM 56 also contains default operation software, which is used to restore the converter to a nominal or "baseline" operation if a bad firmware download occurs. As explained below, if an error is detected in the receipt of downloaded firmware, or if the firmware is found to be invalid, the converter is forced to execute only the default operation software stored in ROM 56.

A timer 64 is associated with microprocessor 50 to provide a time-out feature that prevents the converter from getting stuck on the secondary

downloadable firmware. Utility meter reading can also be provided, by adding an asynchronous data port to the converter and controlling the retrieval of utility data via downloaded firmware.

A flowchart illustrating a routine which can be used by the addressable controller in connection with the receipt and downloading of firmware is provided in Figure 3. The routine begins at box 80, and at box 82 a determination is made as to whether a firmware update has been received from the firmware development system. If so, control passes to box 84 and the new firmware data is encrypted. At box 86, the encrypted data is loaded into the secondary data channel transmitter (firmware modulator 24) and continuously transmitted on the secondary channel together with other firmware packages that can be provided to converters on the system.

At box 88, a determination is made as to whether a new firmware package assignment has been made by billing system 22. If so, addressable controller 14 sends an appropriate command on the primary channel (control data modulator 26) as indicated at box 90. The command is addressed to the particular converter that is to receive the firmware, and identifies the channel the firmware is to be received from, identifies the firmware package to be received, provides the decryption key necessary to decrypt the firmware data, identifies the number of segments which make up the complete firmware package, and sets forth the time-out parameter defining the maximum time the converter should stay tuned to the secondary channel for receipt of the downloaded firmware.

The converter receives the firmware in fixed length "segments", and specific converter models will have specific maximum segment numbers determining the actual maximum size of allowable firmware downloads. In a preferred embodiment, the maximum segment number is a hard-coded parameter. Should an attempt be made to download firmware that exceeds the maximum size, the download will be rejected by the converter. In operation, the converter will ignore the download command and will not switch to the secondary channel if the transmitted maximum segment number parameter exceeds the internal converter maximum.

At box 92 of Figure 3, a determination is made as to whether an abort of a download is required. This would be the case, for example, if the addressable controller detects a problem with an attempted download. In the event an abort is required, an abort command is transmitted over the secondary channel as indicated at box 94. The converter will then switch back to the primary channel, execute the default operation software to return to a baseline operation, and await a subsequent com-

mand from the addressable controller via the primary data channel. At box 96, the routine of Figure 3 ends. It will be appreciated by those skilled in the art that the routine of Figure 3 is called on a periodic basis (or can be a continuous loop) to enable new firmware to be received from the firmware development system and to download firmware packages to converters at the command of billing system 22.

Figure 4 illustrates a routine that the addressable controller can use to continuously transmit firmware data over the secondary channel. The routine commences at box 100, and at box 102 data is transmitted over the secondary channel. At box 104, a determination is made as to whether the last segment of a firmware package has been transmitted. If not, transmission of the remaining segments continues as indicated at box 102. Once the last segment has been transmitted, control passes to box 106 and the addressable controller transmits a check/execute command to the converter(s) that was to receive the firmware package. The check/execute command includes the firmware package number that was to be received, and a check pattern. The check pattern is used to verify the entire download prior to execution. When a check/execute command is received, the converter checks to see if all required segments have been received, and that the check pattern downloaded matches the pattern calculated from the actual downloaded data. If all checks are valid, the converter permits execution of the downloaded code, and returns to the primary data channel. After the check/execute command is sent at box 106 of Figure 4, control returns to box 102, and continuous transmission of the data proceeds over the secondary channel.

Figure 5 is a flowchart illustrating the capture of downloaded firmware by a converter. The routine begins at box 110, and control passes to box 112 where a determination is made as to whether a firmware capture command has been sent to the converter. If not, the converter continuously waits for such a command to be received at box 112.

Once a firmware capture command is received, control passes from box 112 to box 120 for the actual capture of the firmware. At the same time, an ancillary time-out process commences as indicated at boxes 114, 116, and 118. A timer counts down the time-out period specified in the firmware capture command. If the time-out period expires before the specified firmware package has been successfully captured, as determined at box 114, control passes to box 116 where the download is aborted and the converter returns to the primary data channel. As indicated at box 118, the default operation software is executed so that the converter can operate in a baseline mode until the

Send Firmware Check Pattern

The "Accept Firmware Download" command is used to initiate the firmware download process. It may be sent to one individual converter or globally to a set of converters that understand a group address. The addressed converter(s) prepares to accept the package number, on the appropriate channel, using the given firmware decryption key and maximum segment number. The firmware download time-out value is also given. Upon reception of this command, the converter goes into its firmware download mode, in which it must not execute any downloaded code.

The "Return to Primary Channel" command is used to force a converter to return to the primary data channel. This command may also be sent in a specific format to an individual converter, or in group format to a set of converters. All converters receiving this command abort the current firmware download, clear their firmware segment bit maps, and exit the firmware download mode.

The "Disallow Downloaded Execution" command explicitly disallows the execution of any downloaded firmware. It may be sent in the specific or group format. All converters receiving this command abort execution of any downloaded firmware, clear their firmware segment bit maps, exit firmware download mode, and execute the default operation software contained in ROM for baseline operation. Another method of prohibiting downloaded firmware from being executed is to send an "Accept Firmware Download" command immediately followed by a "Return to Primary Channel" command.

The "Load Firmware Segment" command is used to download the individual segments of a firmware package. All converters receiving this command, if in firmware reception mode, overwrite the appropriate segment of firmware by the received data. Before actually overwriting the code, the converter checks to see if the package number matches the commanded package number, and calculates the segment check pattern from the received data. If the check pattern is correct, the segment data is decrypted, the appropriate prior segment is overwritten with the new segment, and the appropriate bit in the firmware segment bit map is set.

The "Check/Execute Firmware" command is used to terminate the firmware download process. All converters receiving this command respond only if the package number matches the one sent originally in the "Accept Firmware Download" command, and if in firmware reception mode. If so, the converter checks to see if all of the necessary segments of firmware have been correctly received. If they have been, the package check pattern is calculated and tested. If the check pattern is

bad, the converter ignores the command. If the check pattern is good, the converter permits execution of the newly downloaded package, switches back to the primary data stream, exits the firmware download mode, and clears its firmware download segment bit map.

The "Send Firmware Check Pattern" command is used to verify the firmware download process. A converter receiving this command responds only if it is not in firmware reception mode. In this event, the converter reports the check pattern of the appropriate segment or of the entire package. This verification scheme is only available on a two-way cable system.

Figure 6 illustrates a periodic self-check routine used by the converter to test the validity of downloaded firmware to ensure that it has not changed since the last download. This self-check is performed by the converter itself, and no addressable controller command is required to initiate it. The routine begins at box 150. At box 152, a clock runs to keep track of time. At box 154, a determination is made as to whether a predetermined time interval has passed. If not, the routine loops back to box 152 and the process continues until the time interval has run. Then, box 154 passes control to box 156 to commence the periodic self-check.

At box 156, the first segment of the firmware package is tested by computing its checksum. At box 158, a determination is made as to whether the checksum is the proper checksum for that segment. If not, control passes to box 160 and the default operation software is executed to return the converter to baseline operation. If the checksum for the segment is proper, control passes to box 162, which determines if the segment just tested is the last segment in the firmware package. If not, the routine loops back to box 156 so that all of the segments in the firmware package can be tested.

Once the last segment has been tested, control is passed from box 162 to box 164 where the clock is reset. Control then loops back to box 152 and the process continues, so that the self-check will be periodically performed at the time interval dictated by the time-out determination function at box 154.

It will now be appreciated that the present invention provides a method and apparatus for remotely modifying the functionality of a terminal, such as a cable television converter. Terminal functions are dictated by downloaded firmware. The firmware is transmitted in small segments to reduce the likelihood and severity of transmission errors, and to reduce the temporary buffering requirements within the terminal. Each section of a firmware package is transmitted with an identifier indicating which segment it is, and which firmware package it is part of. A multiplicity of firmware

frequency agile data receiver means for receipt of addressable data from a cable television headend on a first channel and for receipt of firmware from said headend on a second channel;
 means for tuning said receiver means to said second channel for receipt of firmware in response to instructions contained in addressable data received on said first channel;
 memory means for storing firmware received on said second channel; and
 processor means coupled to said memory means for accessing and executing firmware received from said headend to provide at least one converter function.

21. The converter of claim 20 further comprising:
 means for verifying the integrity of firmware received on said second channel; and
 means for causing said processor means to execute default operation software instead of said firmware in the event the integrity of said firmware is not verified.

22. The converter as defined in one of claims 20 or 21 further comprising:
 timer means for returning said receiver to said first channel if it has been tuned to said second channel for a predetermined time period.

23. The converter of claim 22 wherein said predetermined time period is specified in instructions contained in addressable data received on said first channel.

24. The converter as defined in one of claims 22 or 23 wherein the length of said predetermined time period is dependent on the amount of firmware to be received.

25. The converter as defined in one of claims 20-24 wherein said firmware implements a functional layout on a keyboard associated with said converter.

26. The converter as defined in one of claims 20-24 wherein said firmware implements a feedback function to assist a user in operating the converter.

27. The converter as defined in one of claims 20-24 wherein said firmware implements a control function for a video recorder coupled to the converter.

28. The converter as defined in one of claims 20-24 wherein said firmware implements a communication protocol for the converter.

29. The converter as defined in one of claims 20-24 wherein said firmware implements a descrambling technique for the converter.

30. The converter as defined in one of claims 20-24 wherein said firmware implements an on-screen display to be provided by the converter to a television coupled thereto.

31. The converter as defined in one of claims

20-24 wherein said firmware implements a user interface to services provided over a cable television network.

32. The converter as defined in one of claims 20-24 wherein said firmware implements an electronic mail capability to be provided over a cable television network.

33. The converter as defined in one of claims 20-24 wherein said firmware implements a viewership monitoring function.

34. Cable television headend apparatus for downloading firmware to an addressable remotely modifiable cable television converter, comprising:
 means for transmitting addressable converter data on a first data channel of a cable television network;

means for transmitting firmware on a second data channel of said cable television network;

means for providing an address in said addressable converter data specific to a particular converter coupled to the network, said address enabling specific data to be received by said converter on said first data channel; and

means for providing instructions in said specific data, said instructions causing said converter to receive firmware transmitted on said second channel.

35. The apparatus of claim 34 further comprising:

means for verifying that firmware downloaded to said converter has been successfully received by the converter.

36. The apparatus as defined in one of claims 34 or 35 further comprising:

billing means for maintaining a record of functions said converter is authorized to have, and for assigning a particular firmware package to be downloaded to said converter on the basis of the authorized functions.

37. A method for providing a cable television converter with functions dictated by downloaded firmware, comprising the steps of:

receiving converter control data from 3 remote headend location;

capturing a designated firmware package, from a set of firmware packages transmitted from said remote headend location, in response to instructions contained in said converter control data;

storing the designated firmware package in a memory provided in said converter; and

executing said firmware to provide at least one converter function dictated thereby.

38. The method of claim 37 wherein the firmware packages are transmitted in encrypted form, said method comprising the further step of:
 decrypting the captured firmware using a key contained in said converter control data.

39. The method as defined in one of claims 37

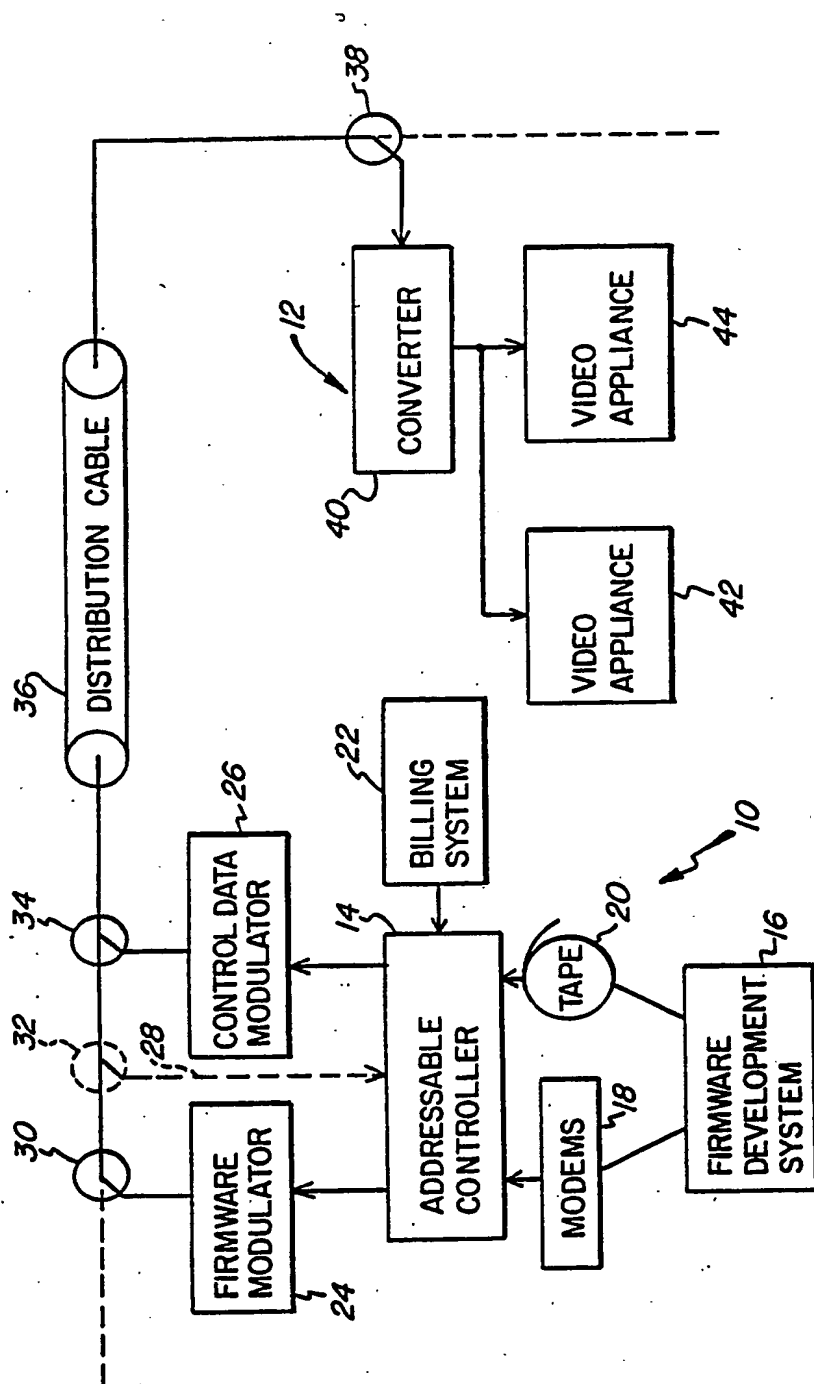
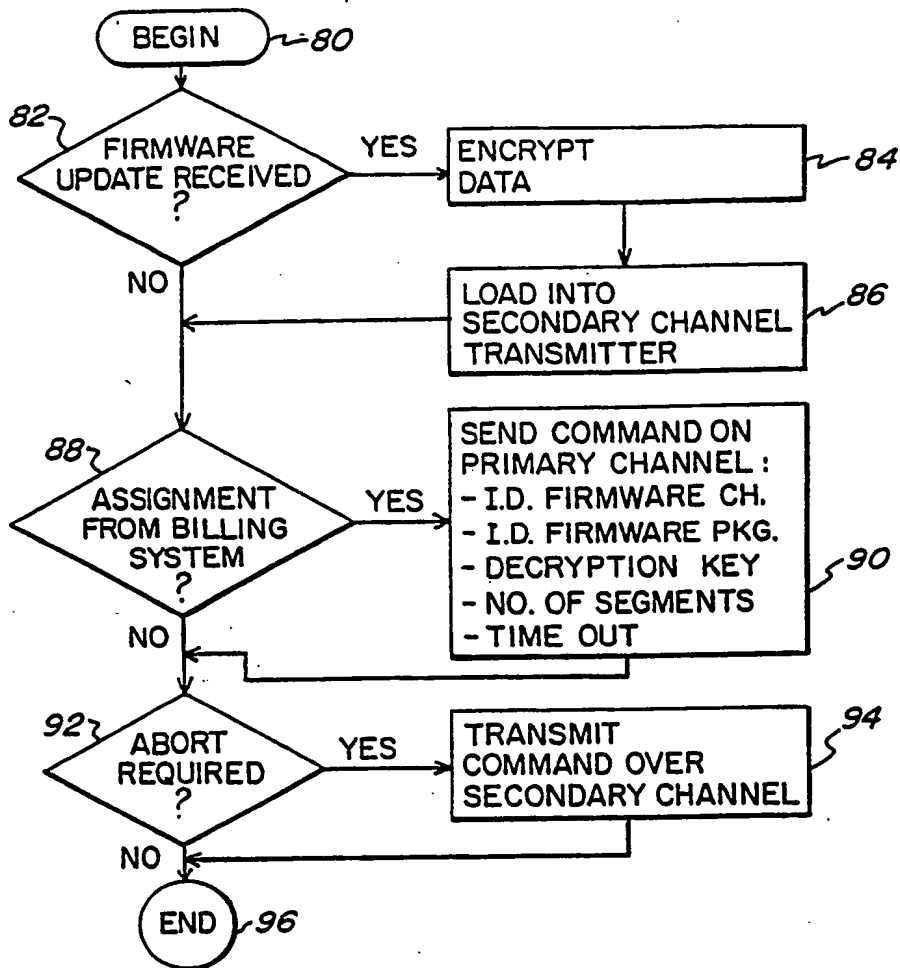
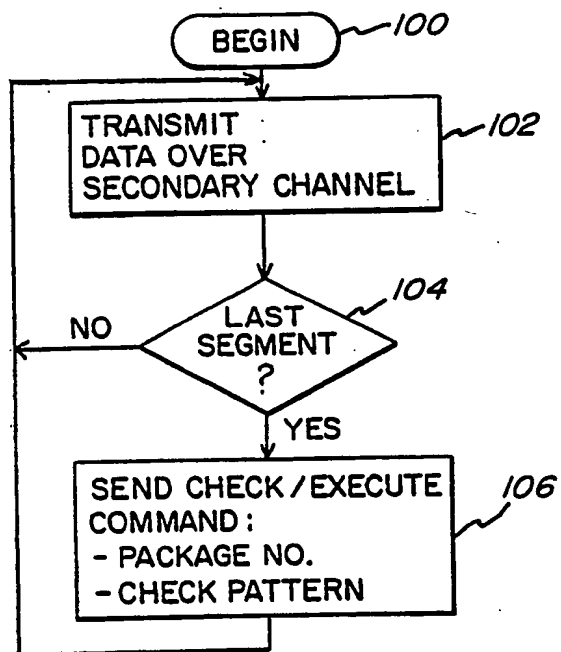


FIG. 1

**FIG. 4**

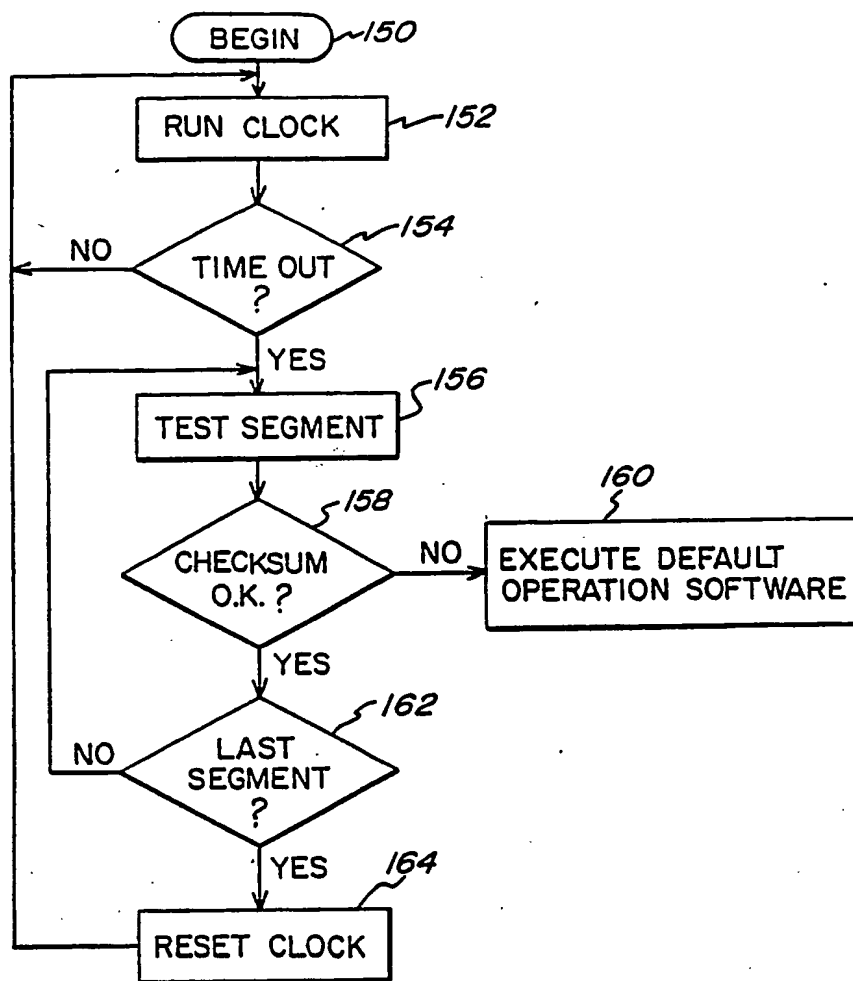


FIG. 6



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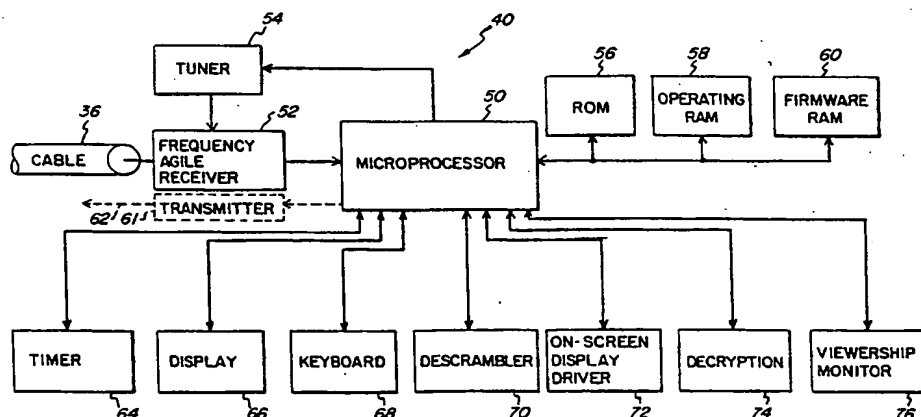
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54 **Functionally modifiable cable television converter system.**

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a first data channel and firmware on a second data channel. The receiver is forced back to the first channel if a successful firmware download does not occur on the second channel within a predetermined time period. The firmware is continuously transmitted in short segments, and the converter can continue to receive segments until all the segments of a designated firmware package have been successfully downloaded, unless the predetermined time limit expires sooner.

FIG. 2





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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid,
namely claims:
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions.

namely:

see sheet -B-

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☒ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid,
namely claims: 1-43
- ☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims.
namely claims:



LACK OF UNITY OF INVENTION A PRIORI

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions,

namely:

1. Claims 1-19: Cable television converter for receiving and verifying firmware downloaded from a headend and for using default software if the firmware is not verified.
2. Claims 20-43: Cable television system for receiving firmware in response to addressable control data from a headend.
3. Claims 44-53: User terminal for securing and verifying segments of a firmware package and for determining if the package is complete.